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DITCHING TESTS WITH A $\frac{1}{11}$-SIZE MODEL OF THE ARMY B-25 AIRPLANE IN NACA TANK NO. 2 AND ON AN OUTDOOR CATAPULT

By George A. Jarvis and Margaret F. Steiner

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NACA CMR No. L4J11

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Army Air Forces, Air Technical Service Command

DITCHING TESTS WITH A $\frac{1}{11}$-SIZE MODEL OF THE ARMY B-25 AIRPLANE IN NACA TANK NO. 2 AND ON AN OUTDOOR CATAPULT

By George A. Jarvis and Margaret F. Steiner

SUMMARY

The tests were made to determine the best way to land the B-25 airplane in calm and rough water and to determine its probable ditching performance. A dynamically similar model of the B-25 airplane was landed in calm water in tank no. 2 and in calm and rough water from the outdoor catapult. Its behavior was determined by making visual observations, by recording longitudinal accelerations, and by taking motion pictures of the landings.

By landing with flaps down in a tail-down attitude at as slow a speed as possible, smooth straight landing runs will probably result in calm water. In moderate winds and regular waves the airplane should be landed along the wave. If the wind is strong or the waves are irregular, the airplane should be landed into the wind; an attempt should be made to contact a wave just after a crest has been passed. Landing in the level attitude will probably result in skipping, porpoising, or swerving.

INTRODUCTION

Object of tests.- The object of the tests was to determine the best way to land the B-25 airplane in calm and rough water and to determine its probable ditching behavior.

Requested.- Army Air Forces, Materiel Command, March 23, 1945.

Date and place of tests.- The tests were made in NACA tank no. 2 in September and October of 1943 and at an outdoor catapult under supervision of impact-basin personnel in December of 1943 and January of 1944.

Full-scale experience.- Reports, from North American Aviation Inc. and from a pilot of the Army Air Forces, of eight ditchings of the B-25 airplane indicate fairly good ditching characteristics. Out of 37 crew members involved, only one death was mentioned as a direct result of the behavior of the airplane in the ditching.

Generally when the crew members were not strapped in or braced they were thrown around considerably, the men in the rear receiving the greatest effect of the pitching. Minor scratches and bruises were usually received and one man was killed after being thrown forward from the camera section.

In one ditching in rough water (into the wind) most of the crew were momentarily unconscious as a result of the shock sustained at impact.

From one to three distinct shocks were generally felt when the airplane struck the water. At the final shock the nose and nacelles plowed in. In one instance the airplane skipped and dived and then bobbed up to the surface. In another instance only a slight shock was felt and the airplane coasted to a stop.

The flotation time reported varied from 1/2 to 11 minutes; the average time was over 4 minutes.

PROCEDURE

Description of Model

Scale.- 1/11 size.

Type of construction.- See reference 1. The nose section of the model was made removable so that a B-25G airplane could be simulated by the installation of the cannon nose.

Photographs.- B-25B, B-25C, B-25D (fig. 1); B-25G, (fig. 2).

Test Methods and Equipment

The apparatus and test procedure are described in reference 1.

Test Conditions

(All values given refer to full-scale airplane.)

Gross weight.- 26,000 pounds (design gross weight); 22,600 pounds (no bombs, half fuel load).

Location of center of gravity.- 25.1 percent of mean aerodynamic chord; 2.71 inches above the thrust line.

Attitude of the thrust line.- 13°, 12° tail down landing attitude; 9°; 6° medium attitude, and 0° level landing attitude.

Landing gear.- Retracted.

Flap setting.- North American Aviation Inc. indicated that the ultimate design load normal to the undersurface of the flap is 216 pounds per square foot; the flaps will probably fail on striking the water. Semifixed flaps simulate flaps which fail on striking the water. Tests were made with the flaps up, 20° down fixed, and 45° down fixed and semifixed.

Landing speed.- The speed range covered on tank tests was from 80 to 120 miles per hour. The speeds used at the outdoor catapult were for power-off flaps-down landings as computed from data furnished by North American Aviation, Inc. They are listed in table I.

Conditions of simulated damage.- Information supplied by North American Aviation, Inc., indicates that the strength of the fuselage is greater than either that of the bombardier's window, the main landing-gear doors, or the entrance hatches. The bomb-bay doors are almost certain to collapse and the bulkhead aft of the

bomb bay is liable to be forced inward.

I - Simulated damage on the model representing the B-25B, B-25C, and B-25D airplanes:

(a) No damage (fig. 1(c))

(b) Model complete with $2\frac{3}{4}$-inch projection from the fuselage skin at after edge of the bomb bays (fig. 3) (simulates denting or tearing of the bottom)

(c) Model complete with $5\frac{1}{2}$-inch projection from the fuselage skin at after edge of the bomb bays (fig. 3) (simulates denting or tearing of the bottom)

(d) Bomb-bay and wheel doors, bombardier's windows, camera hatch, and bulkhead at after end of the bomb bay all removed (fig. 4) (catapult tests were made at this condition)

(e) Same as (d) plus failure of entrance hatches (fig. 5)

(f) Same as (e) except bulkhead in after end of bomb bay left intact (fig. 6)

II - Simulated damage on the model representing the B-25G airplane:

(a) Bomb-bay and wheel doors, camera hatch, and the bulkhead at the after end of the bomb bay all removed (fig. 2)

Propellers.- The effect of propellers was determined with windmilling propellers. The damage simulated was the same as in I(e) above (fig. 7).

Condition of seaway.- (a) Calm water

(b) Wave crests parallel to the flight path, height approximately 1 to 6 feet, length approximately 20 to 120 feet

(c) Wave crests perpendicular to the flight path, height 1 to 4 feet, length approximately 20 to 80 feet

RESULTS

The results are presented in tables II and III.

Photographs showing the characteristic behavior are shown in figures 8 through 11.

Time-history records of longitudinal accelerations are shown in figures 12 and 13.

DISCUSSION

At high attitude, smooth landing runs generally resulted. At low attitudes skipping, porpoising, or turning occurred. In tank tests the maximum decelerations were less than 5g, while the average of these maximum values for all conditions tested was less than 3g. The decelerations at the outdoor catapult in rough water were higher and of the order of 4g to 7g. The maximum recorded longitudinal deceleration was in a diving turn in smooth water.

Effect of attitude.- When ditched at the 12° attitude, the model rode in the water with the tail of the fuselage deep in the water and heavy spray was thrown from the nacelles on to the tail surfaces. Near the end of the run the attitude decreased and the nacelles dug in and threw some spray forward. The model generally ran from 2 to 5 lengths. In rough water the model sometimes nosed into a wave and the run was shortened.

In all of the tests from the catapult at 12° and 9° attitudes, the model's elevator had little aerodynamic effect, and frequently the model did not keep in trim before it contacted the water surface. This might account for some of the digging in of the nose and nacelles early in the runs.

In tank tests, ditchings at the 6° attitude were very similar to the high-attitude runs, since on striking the water the model assumed about the same attitude as in a 12°-attitude ditching. The runs were, however, generally about 1 length longer than at the 12° attitude. In rough-water tests, porpoising developed and the model tended to dig into the waves.

The level-attitude landings were made at speeds lower than the full-scale landing speeds for the flap and power condition represented. The results, therefore, may not be truly applicable to the level landing of the full-scale airplane.

In ditchings at 0° the fuselage and nacelles struck the water almost simultaneously, the nacelles threw some spray, and the model generally skipped, porpoised, or made sharp turns.

Effect of flap setting.- In all of the rough-water tests and most of the calm-water tests, the semifixed flaps deflected upward upon hitting the water (simulating their failure) and had no direct effect on the hydrodynamic performance. However, by landing with flaps full down, the speed was lowered and the ditching performance was improved.

Some runs were made with no damage simulated on the model and with the flaps rigidly fixed in three positions: up, at 20°, and at 45°. When the flaps were in the deflected positions there was a tendency to skip and swerve.

Effect of simulated damage.- Simulating failure of the bomb-bay and wheel doors, bombardier's window, camera hatch, and the bulkhead aft of the bomb bays did not seriously affect the behavior of the model. At the 6° and 0° attitudes the model even made slightly longer runs with lower maximum deceleration when damage was simulated. When the bulkhead at the aft end of the bomb bay remained intact, the length of the run was greater than when the bulkhead was carried away, but porpoising occurred at 6° and skipping, at 0°.

A ridge was added to the fuselage of the model just aft of the bomb doors to represent a damaged condition of the structure. When the ridge height was increased to $5\frac{1}{2}$ inches (full size), violent dives occurred. This projection was rigidly attached and the results are probably pessimistic since projecting parts due to damage would probably be flexible and would not offer such great resistance to the water.

The general behavior of the model representing the B-25G with an undamaged nose section but with simulated failure of the bomb-bay and wheel doors, camera hatch,

and the bulkhead aft of the bomb bay was very nearly the same as that for the model representing the B-25B, B-25C, and B-25D, but the length of run was about 1 length longer.

Effect of propellers.- The windmilling propellers increased the maximum deceleration and shortened the length of landing run. The results may be somewhat pessimistic because the propellers did not bend at the tips but, even so, these results indicate that the propellers were not severely detrimental to the ditching characteristics.

Effect of seaway.- When moderate winds existed and the waves were fairly smooth and appeared in regular trains, the best ditching was made along the wave.

When stiff winds existed and the water was rough and breaking, the model behaved better if landed into the wind and across the waves. Landing across the wind along rough and breaking waves frequently resulted in a shallow dive. Since the danger of digging into a wave existed even when landing along a wave, in a rough sea, better performance resulted by landing into the wind as the speed relative to the water was reduced.

When landing across the waves the performance was best if the tail was touched down on the windward side of a wave so that the airplane was not tripped and forced to enter nose down in an oncoming wave.

CONCLUSIONS

From results of the tests with the $\frac{1}{11}$-size model the following conclusions were drawn:

1. The airplane should be landed in the tail-down attitude (12°, thrust line).

2. The landing should be made with the flaps fully extended to obtain the slowest possible speed.

3. When moderate winds and regular waves exist the airplane should be landed parallel to the waves. When stiff winds or irregular waves exist, the airplane

should be landed into the wind, across the waves, preferably making contact tail first near the top on the windward side of the wave.

4. If the airplane is ditched in calm water in a tail-down attitude it will probably make a smooth run of about 2 to 5 lengths. The maximum acceleration will probably be between 2g and 4g. In rough water if the airplane, landing into the wind, contacts a wave on the windward side it will probably make a smooth run.

5. If a landing is made with a wing low or if the tail is thrown up by hitting a wave, the nose may be forced to dig into an oncoming wave and accelerations as high as 7g will be experienced. If denting or tearing occurs in such a manner as to form a rigid projection of 4 or 5 inches aft of the bomb bay, severe diving may result.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., October 11, 1944

REFERENCE

1. Fisher, Lloyd J., and Steiner, Margaret F.: Ditching Tests with a $\frac{1}{12}$-Size Model of the Army B-26 Airplane in NACA Tank No. 2 and on an Outdoor Catapult. NACA MR, Aug. 15, 1944.

TABLE I. - LANDING SPEEDS USED AT THE OUTDOOR CATAPULT

All values are full scale.

Weight (lb)	Attitude fuselage reference line (deg)	Airspeed (mph)
22,600	13	89
26,000	12	94
22,600	9	98
26,000	6	112
26,000	0	145

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TABLE II.- DECELERATIONS AND LENGTHS OF RUNS OF A $\frac{1}{11}$-SIZE MODEL OF THE B-25 SERIES AIRPLANE DITCHING ON CALM WATER

[Gross weight 26,000 lb full size]

Flap settings	Thrust line attitude	12° tail-down landing								6°									0° level landing		
	Speed, mph, full scale	80			100			120		80			100			120			120		
	Condition of Model / See note	Max	Run	Rmk	Max	Run	Rmk	Max	Run	Max	Run	Rmk	Max	Run	Rmk	Max	Run	Rmk	Max	Run	Rmk
Up	(a) Complete; simulating no structural failure				2.5	4		2.9	6				3.0	4		3.0	5		3.6	4	
20° down fixed													2.7	5	t	3.3	6	ts	3.3	8	s
45° down fixed		2.4	3	t	2.4	4				1.3	4	t	2.0	4	t				2.8	4	t
45° down semi-fixed		2.4	2		3.5	4				2.9	2		3.2	3					3.8	5	t
	(b) Model complete; $2\frac{3}{4}$ in. ridge at after edge of bomb bay		2	d_2t		2	d_2t													3	t
	(c) Model complete; $5\frac{1}{2}$ in. ridge at after edge of bomb bay		1	d_1		2	d_1														
	(d) Simulated failure of wheel and bomb-bay doors, bombardier's window, camera hatch, and the bulkhead at after end of bomb bay	2.7	2		3.5	3				2.3	3		2.9	5					2.3	7	s
	(e) Simulated failure same as (d) plus failure of entrance hatches	3.9	2		3.7	4				2.5	2		2.2	5					2.1	7	s
	(f) Simulated failure same as (e) except bulkhead remained intact	2.8	4		2.8	5				2.0	5	p	1.9	6	p				2.0	6	s
	(g) Model with windmilling propellers; simulated failure same as (e)	4.1	2		3.8	3				3.2	2		3.5	3					4.0	4	
	(h) Model G airplane simulated failure same as (d) except nose remained intact	2.6	4		3.1	5				2.3	5		2.7	6					3.2	6	p

Note:

Max – Maximum deceleration in multiples of the acceleration of gravity
Run – Length of run in multiples of length of the model
Rmk – Remarks (See symbols.)

Symbols:

d_1 violent dive
d_2 slight dive
t sharp turn or swerve
s skipped
p porpoised

TABLE III.- DITCHING TESTS AT THE OUTDOOR CATAPULT WITH A $\frac{1}{11}$-SIZE MODEL OF THE ARMY B-25 AIRPLANE

[All values are full scale]

Flight data and results						
	Attitude (deg)	Weight (lb)	Wave height range (in.)	Wind velocity range (mph)	Range maximum recorded longitudinal deceleration (g)	Performance
Across waves, into wind	13	22,600	32 to 44	25	3 to 6	If the nose entered a wave, the model stopped abruptly. If the nose rode over the wave, smooth run resulted.
	9	22,600	11 to 22	11 to 23	3 to 5	Porpoising was evident. Nose and nacelles raised heavy spray.
Along waves, across wind	13	22,600	28 to 44	15	4.4 to 5.3	Pitched up and down in smooth run.
	12	26,000	11 to 22	10		Rode low in water during much of run (speeds were low for this weight).
	9	22,600	66	23	5 to 6	Nose and nacelles dug in during run.
Smooth water	13	22,600	6	Calm	3 to 4.6	Sometimes the model pitched up in the water; smooth runs resulted. Otherwise the model swerved and short runs resulted. The model tended to dig in in heavy weight runs. (One reason may have been that the speeds were low and thus the lift of the wing was less than the weight of the model.)
	12	26,000		Calm		
	9	22,600	0	Calm	5 to 7.4	Turned in all runs (since one wing was slightly low before contact).
	6	26,000	0	Calm		Porpoising evident. Fairly heavy spray raised.
	0	26,000		Calm		Speeds all low as in "pancake" landing. Nose and nacelles dug in deeply through most of run. Tended to porpoise and swerve.

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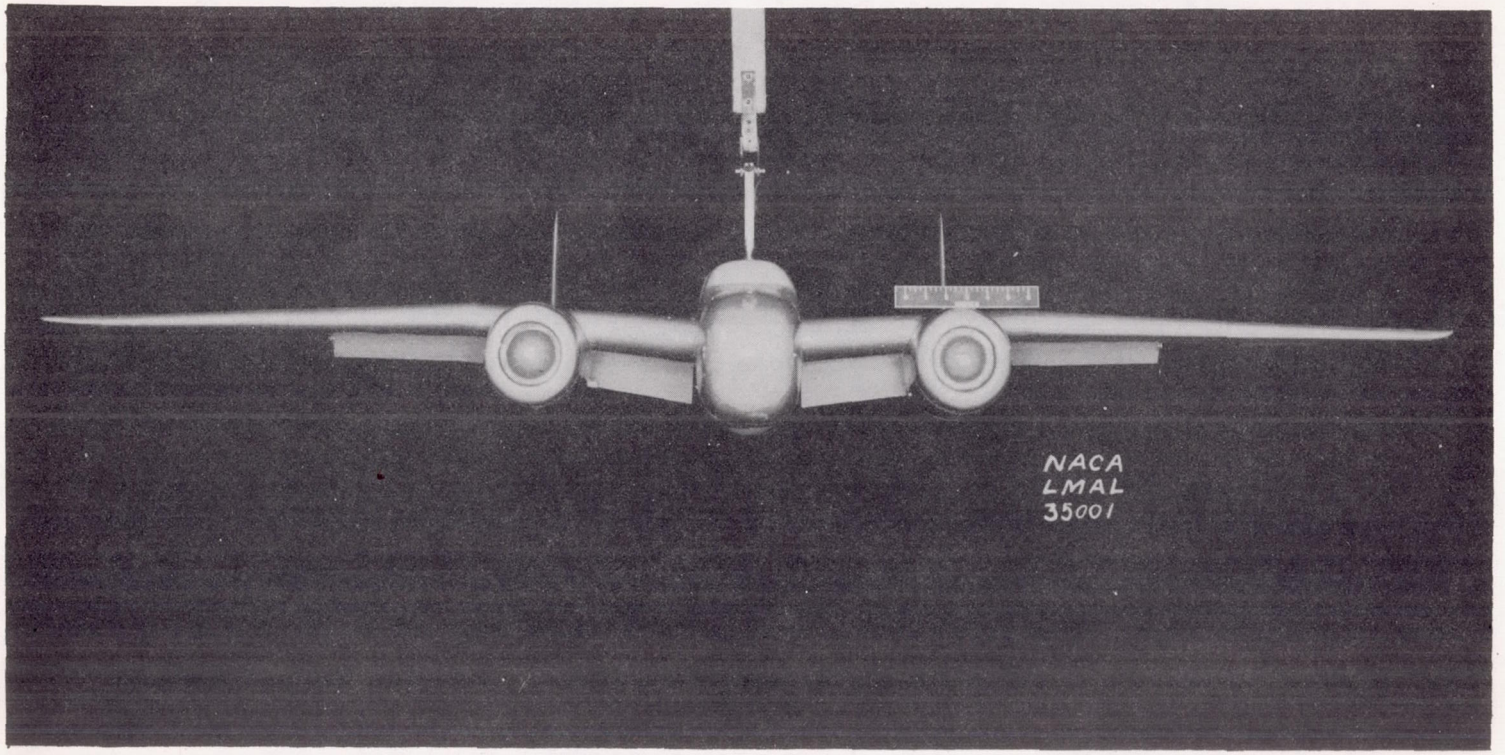

Figure 1a.- Front view of a $\frac{1}{11}$-size model of the B-25 airplane.

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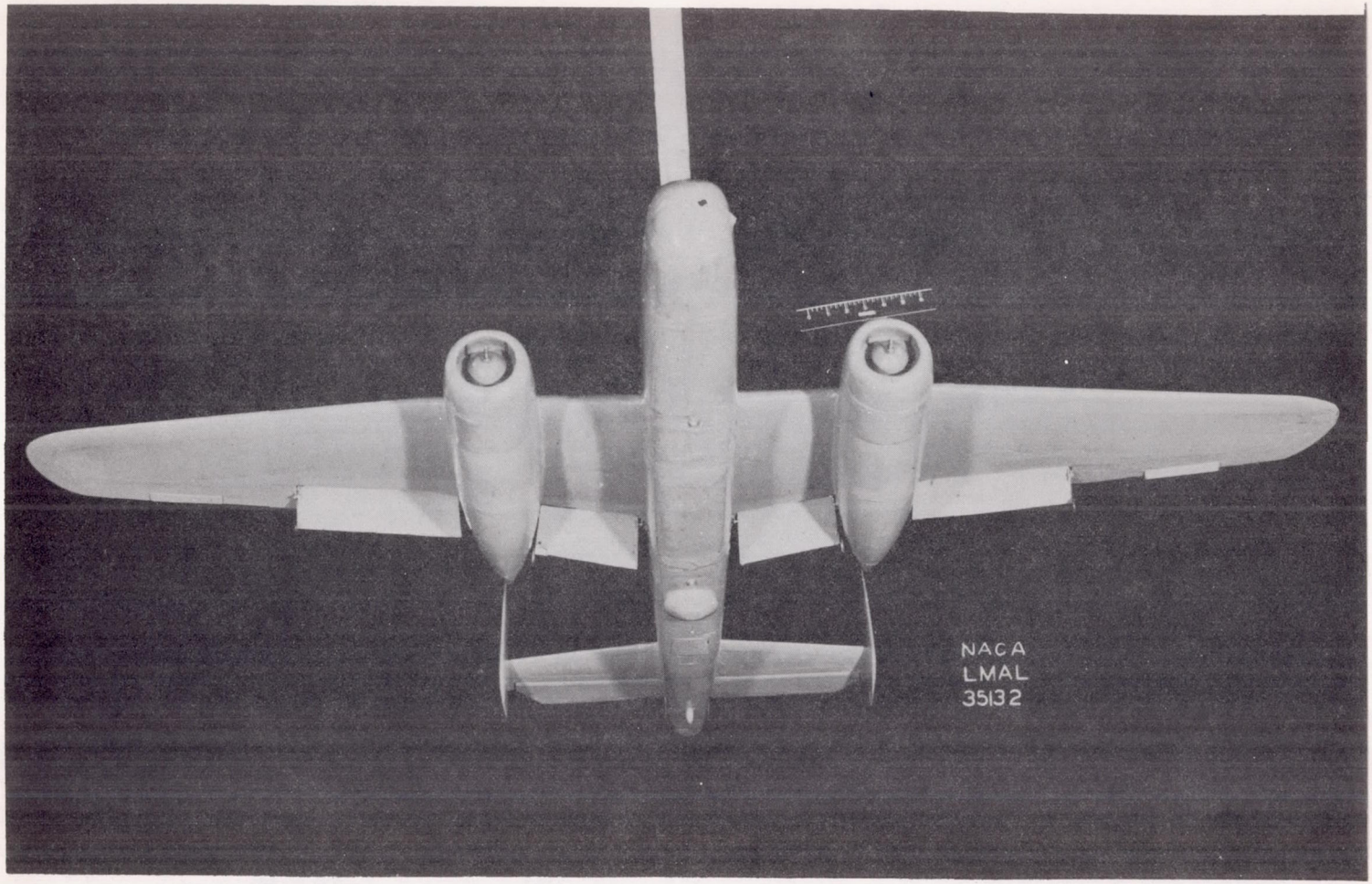

Figure 1b.- Bottom view of a $\frac{1}{11}$-size model of the B-25 airplane.

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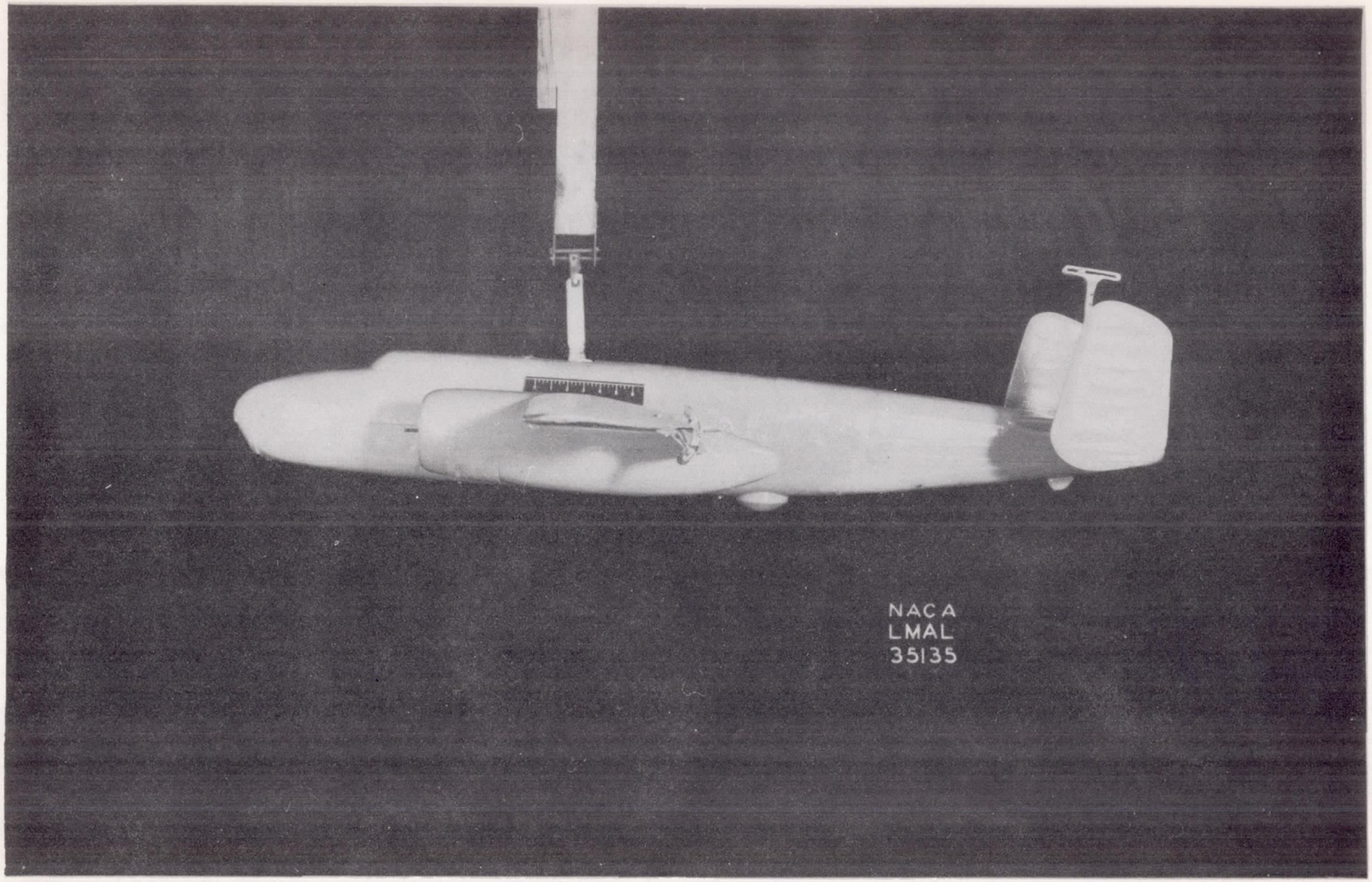

Figure 1c.- Side view of a $\frac{1}{11}$-size model of the B-25 airplane.

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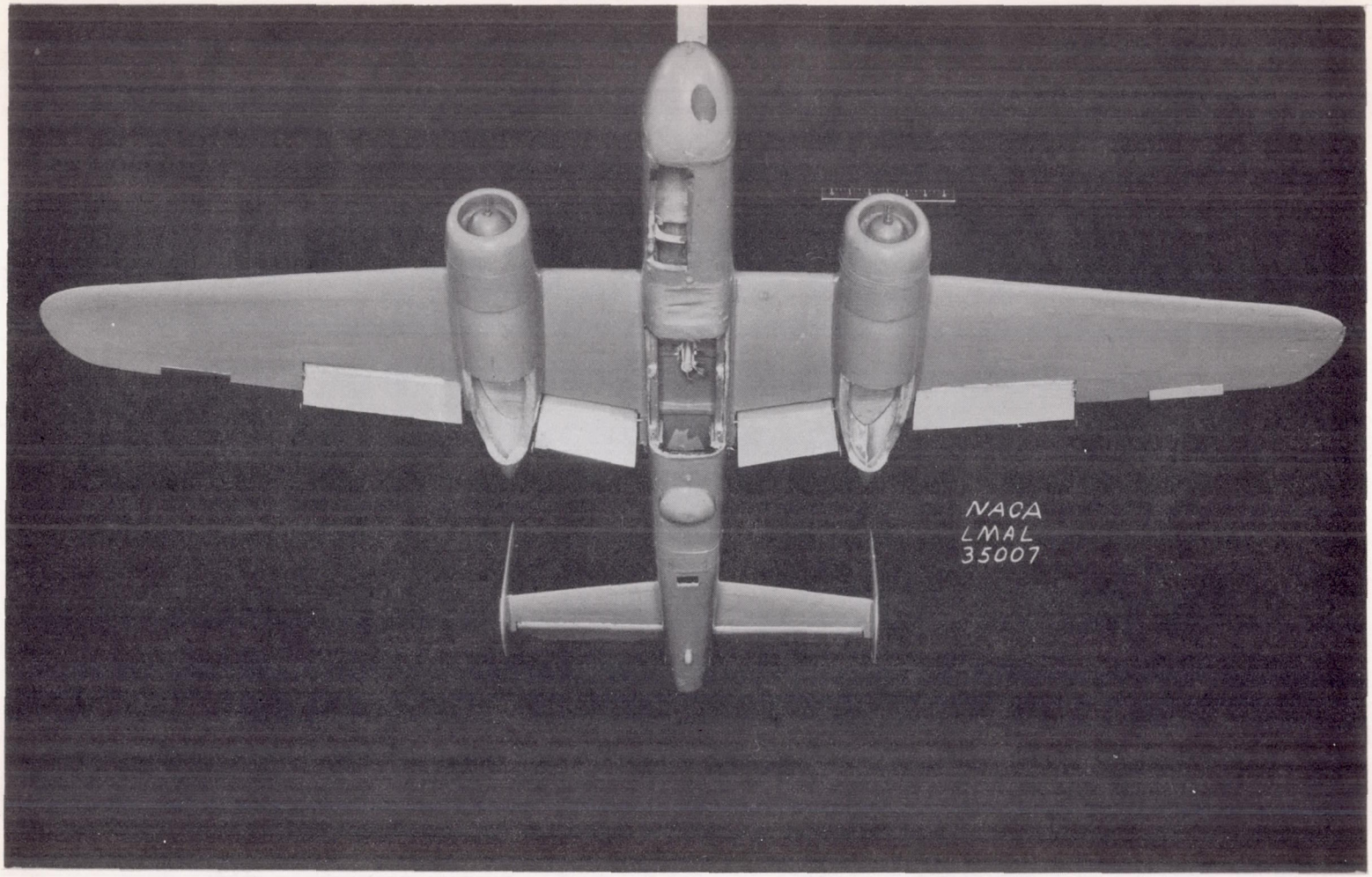

Figure 2a.- Bottom view of a $\frac{1}{11}$-size model of the B-25G airplane, showing openings cut out to simulate failure of the wheel doors, bomb-bay doors, camera hatch, and bulkhead at the after end of the bomb bay.

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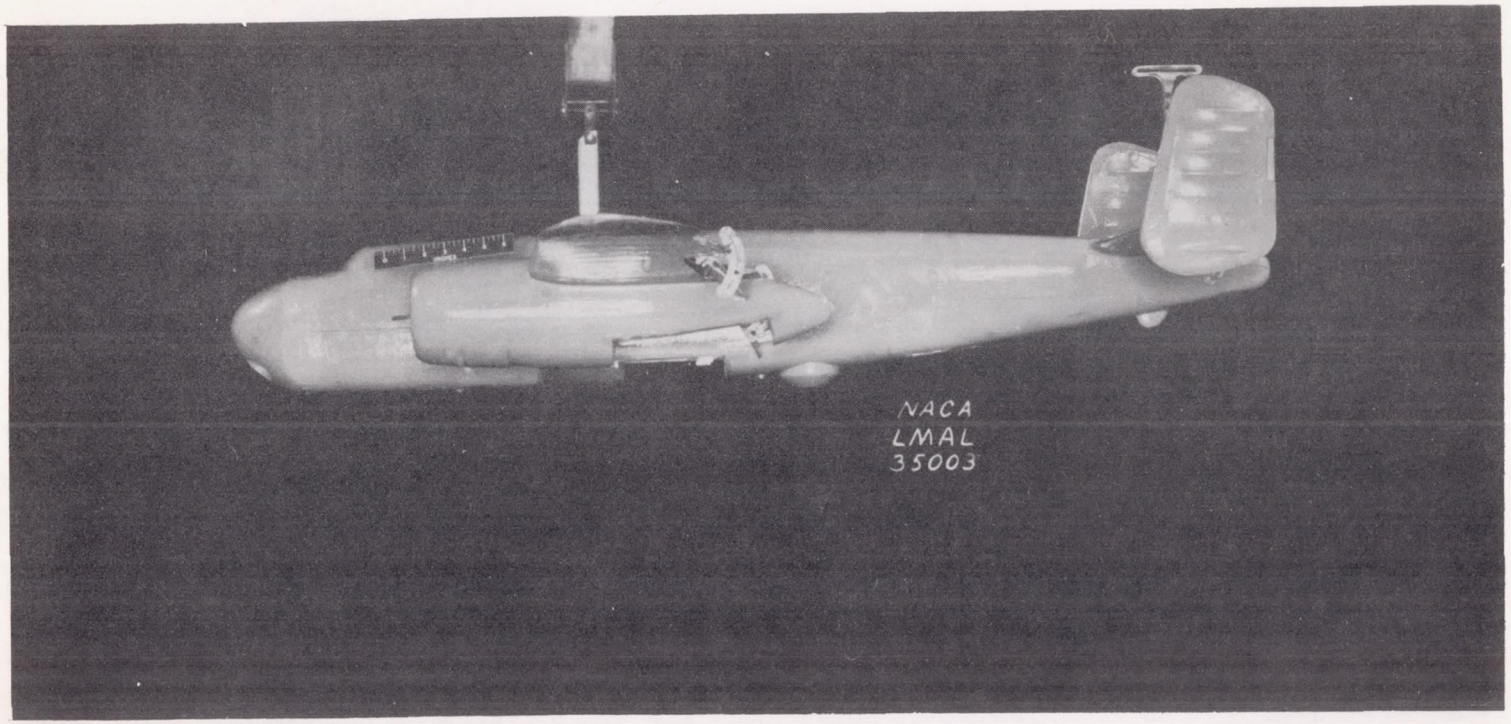

Figure 2b.- Side view of a $\frac{1}{11}$-size model of the B-25G airplane showing openings cut out to simulate failure of the wheel doors, bomb-bay doors, and camera hatch.

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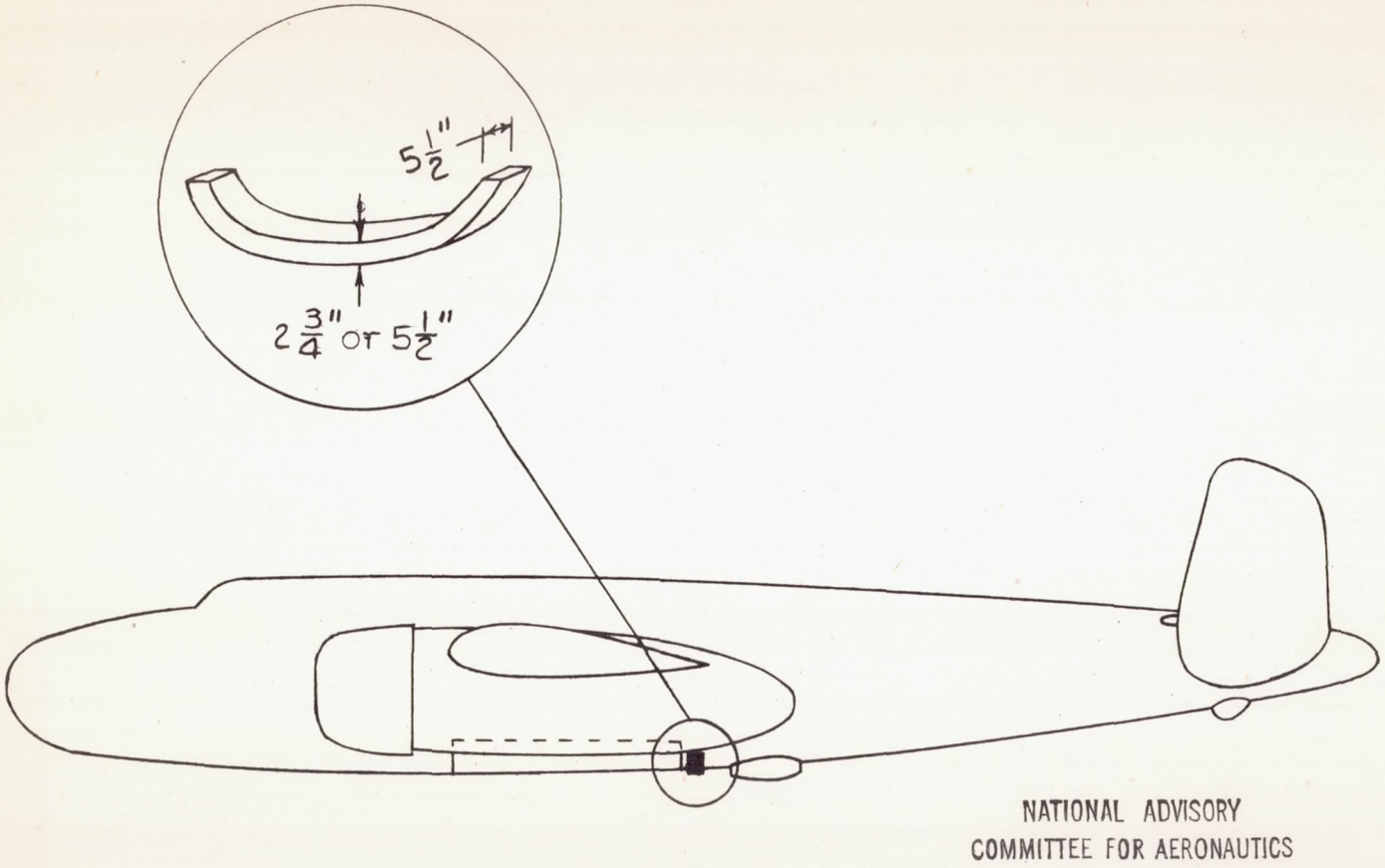

Figure 3. - Projecting ridge as tested on the model of the B-25 airplane. (Dimensions are for the full-size airplane.)

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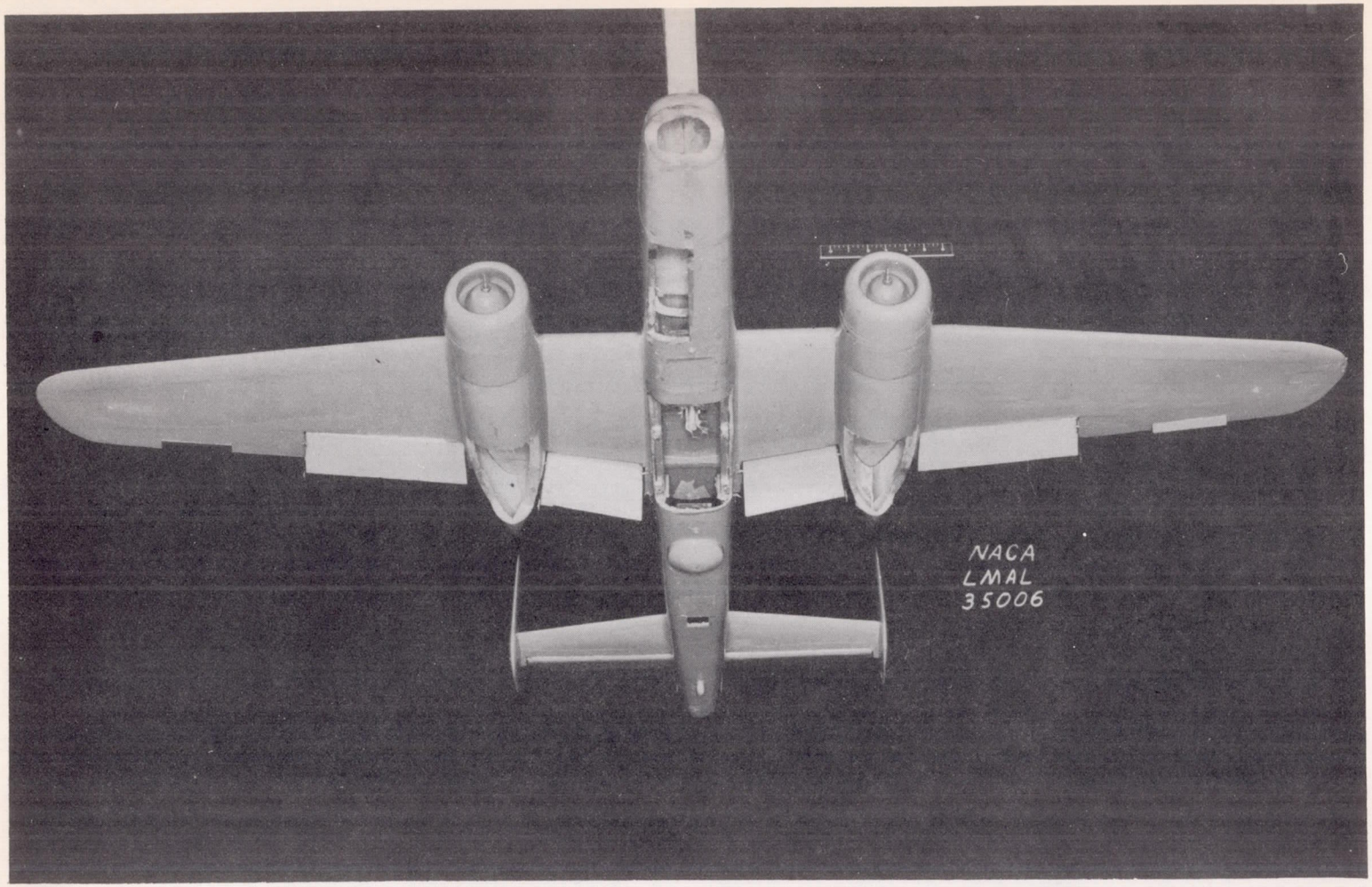

Figure 4.- Photograph of a $\frac{1}{11}$-size model of the B-25 airplane with simulated damage of wheel and bomb-bay doors, camera hatch, bombardier's window, and the bulkhead at the after end of the bomb bay.

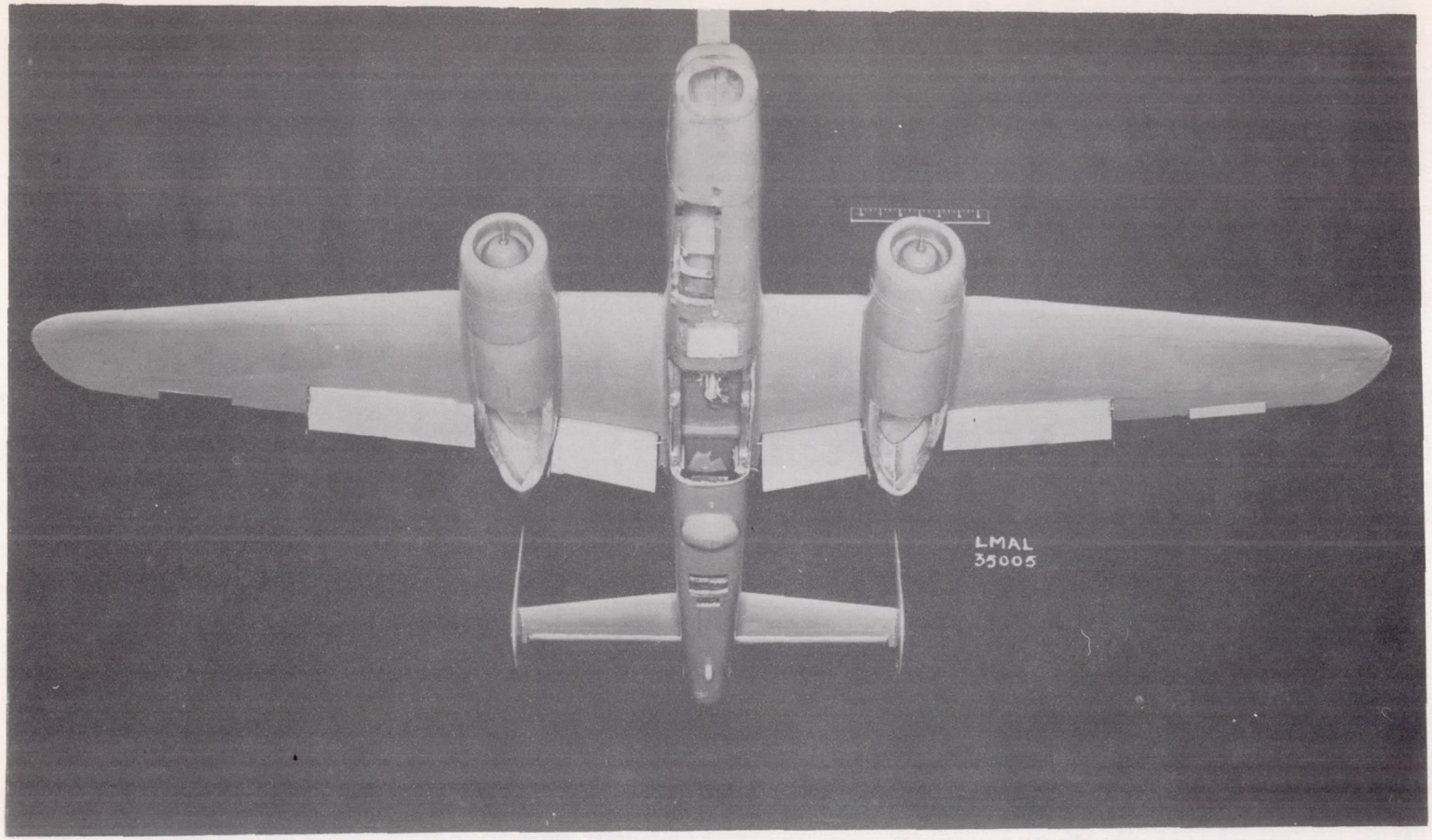

Figure 5.- Photograph of a $\frac{1}{11}$-size model of the B-25 airplane with simulated damage of wheel and bomb-bay doors, camera and entrance hatches, bombardier's window, and the bulkhead at the after end of the bomb bay.

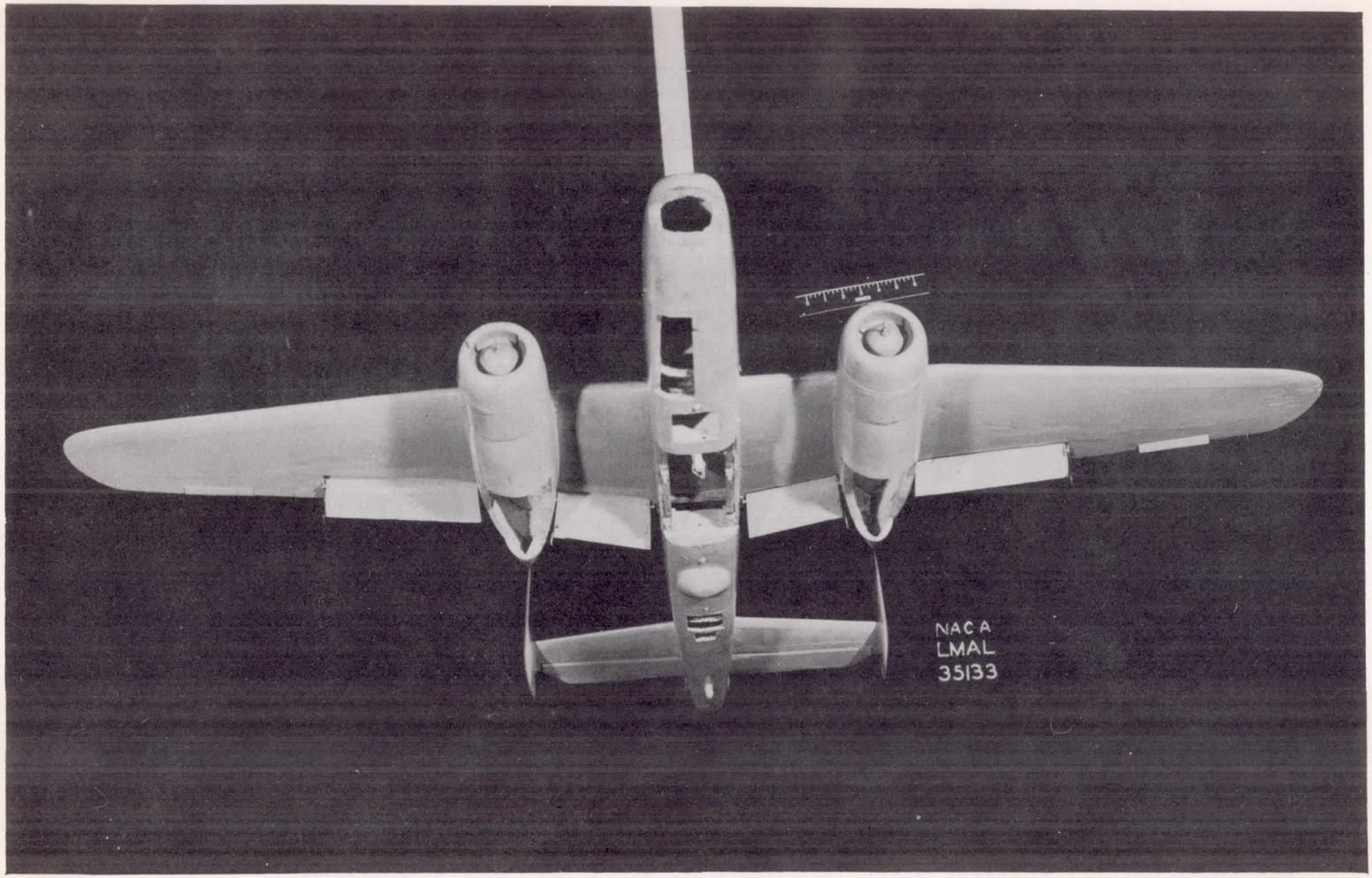

Figure 6.- Photograph of a $\frac{1}{11}$-size model of the B-25 airplane with simulated damage of wheel and bomb-bay doors, camera and entrance hatches, and bombardier's window.

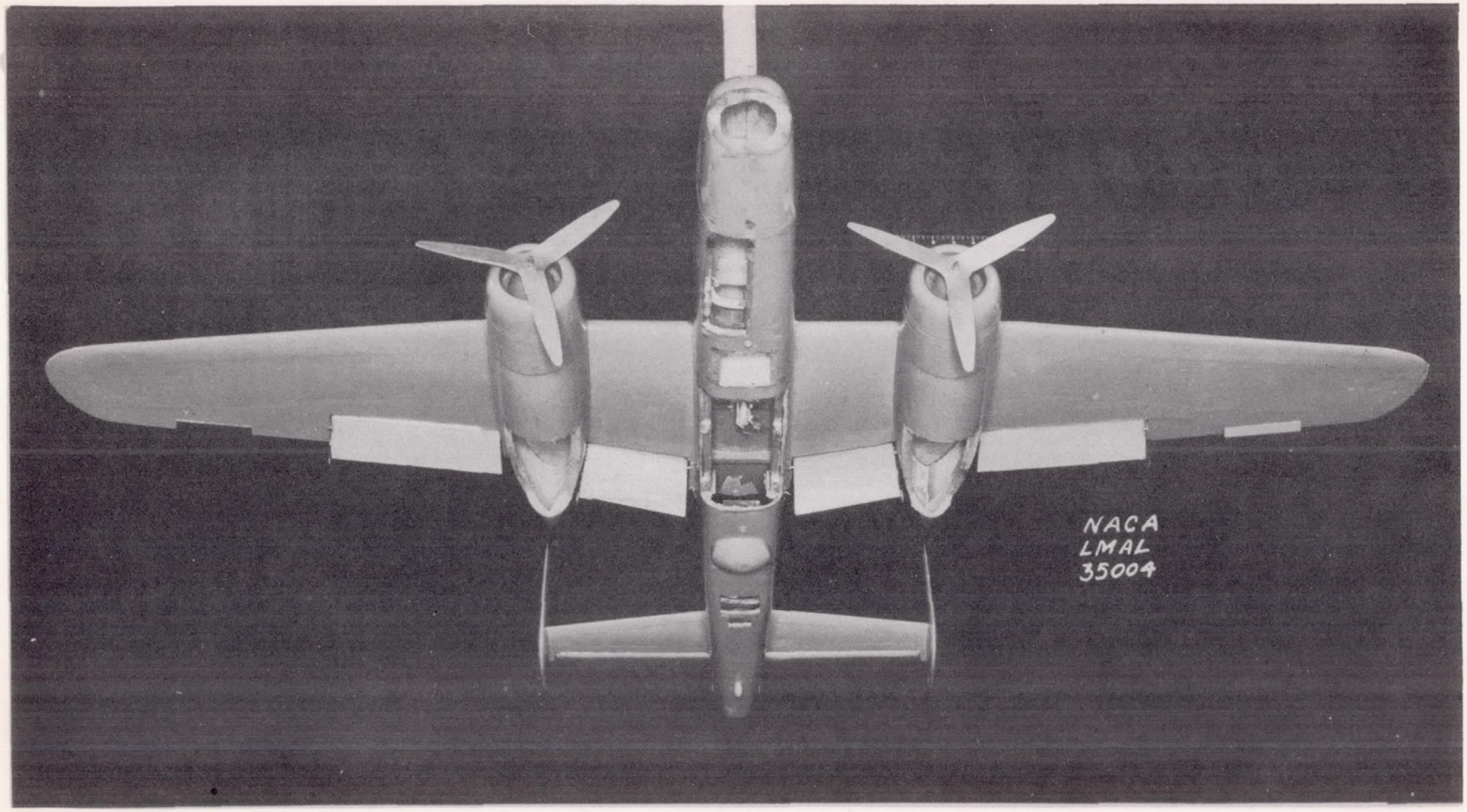

Figure 7.- Photograph of a $\frac{1}{11}$-size model of the B-25 airplane with propellers.

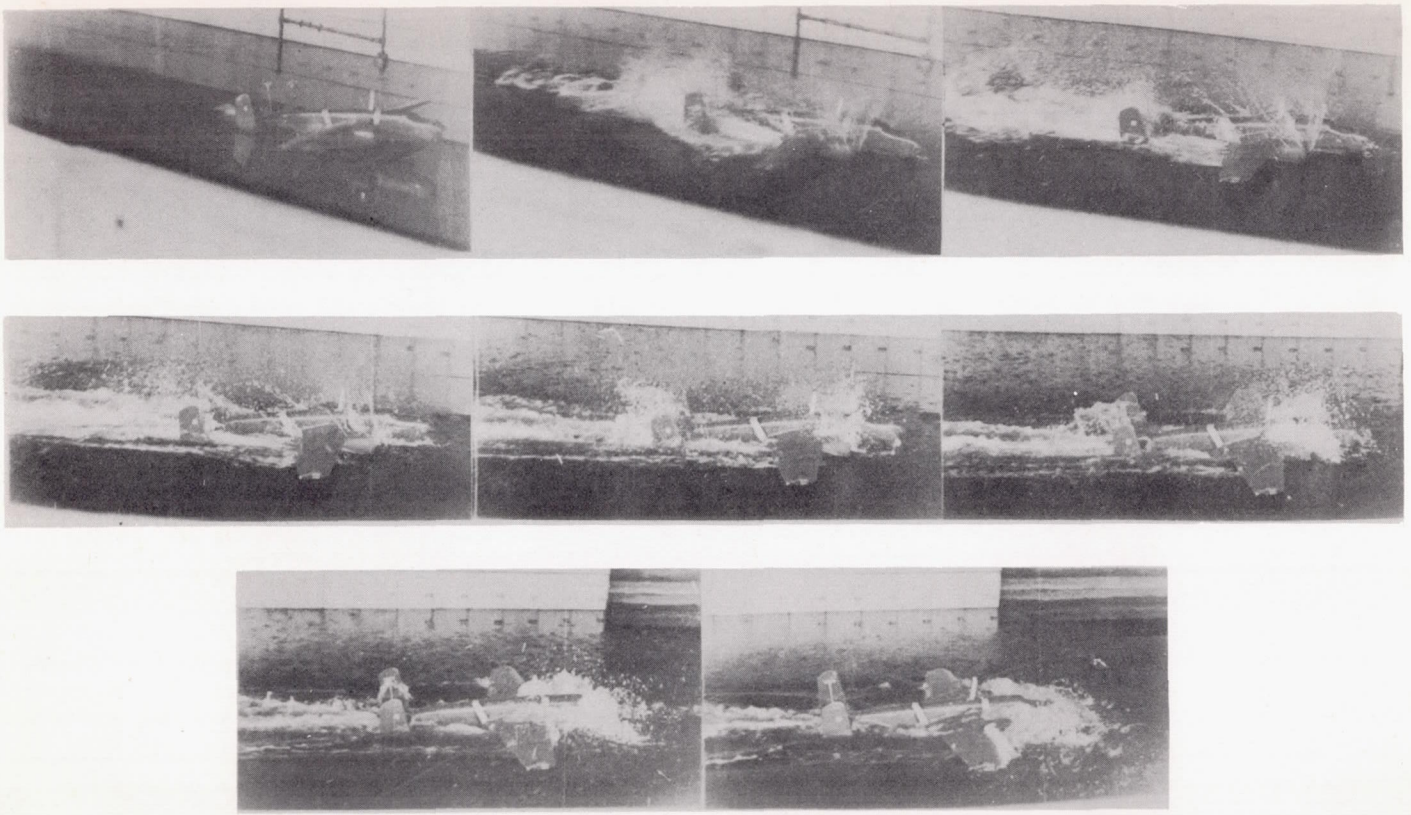

Figure 8.- Photographs of a ditching of a model of a B-25 airplane (0.83-second intervals full scale) Attitude 12°; flaps down 45° semifixed; speed, 80 miles per hour full scale. Simulated failure of wheel and bomb-bay doors, camera and entrance hatches, bombardier's window, and bulkhead at after end of bomb bay.

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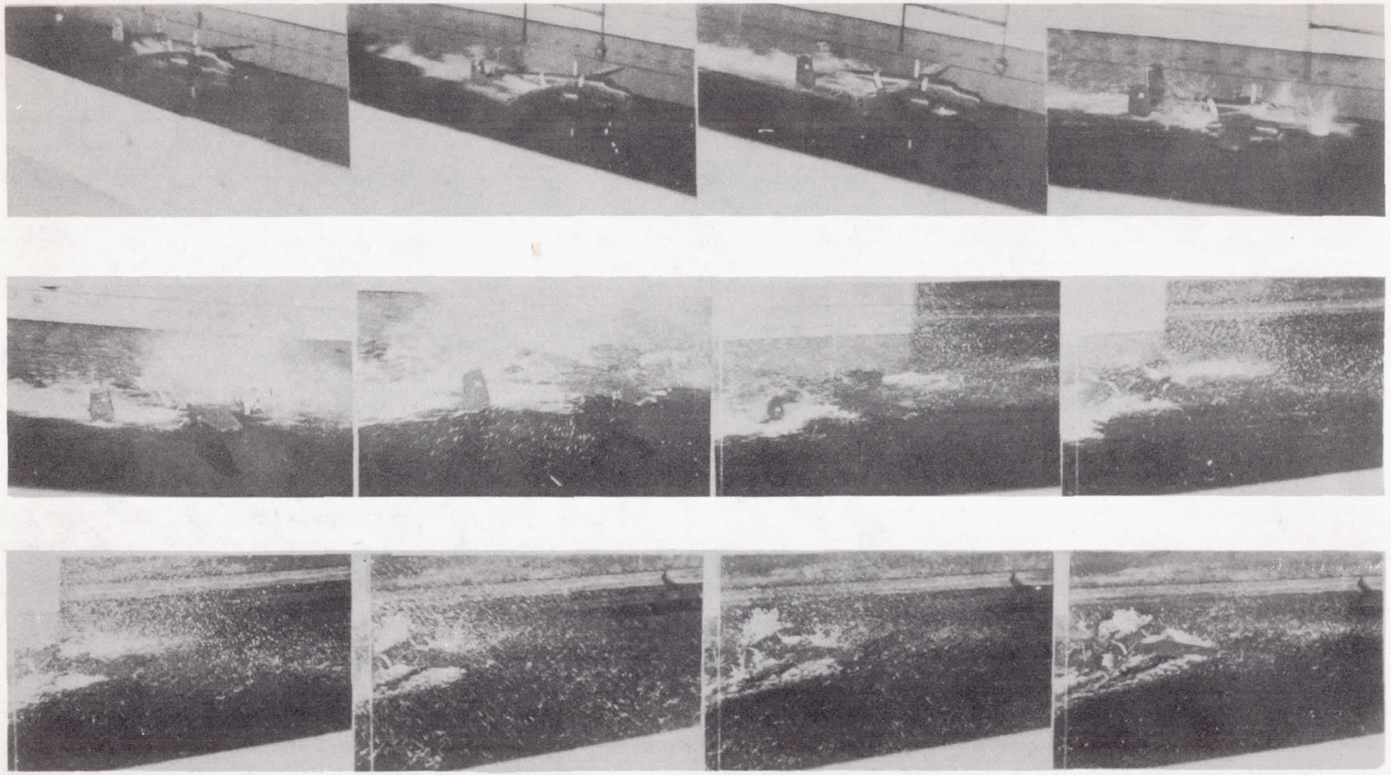

Figure 9.- Photographs of a ditching of a model of a B-25 airplane (0.415-second intervals full scale). Attitude 0°; flaps down 45° semifixed; speed, 120 miles per hour full scale. Simulated failure of wheel and bomb-bay doors, camera and entrance hatches, bombardier's window, and bulkhead at after end of bomb bay.

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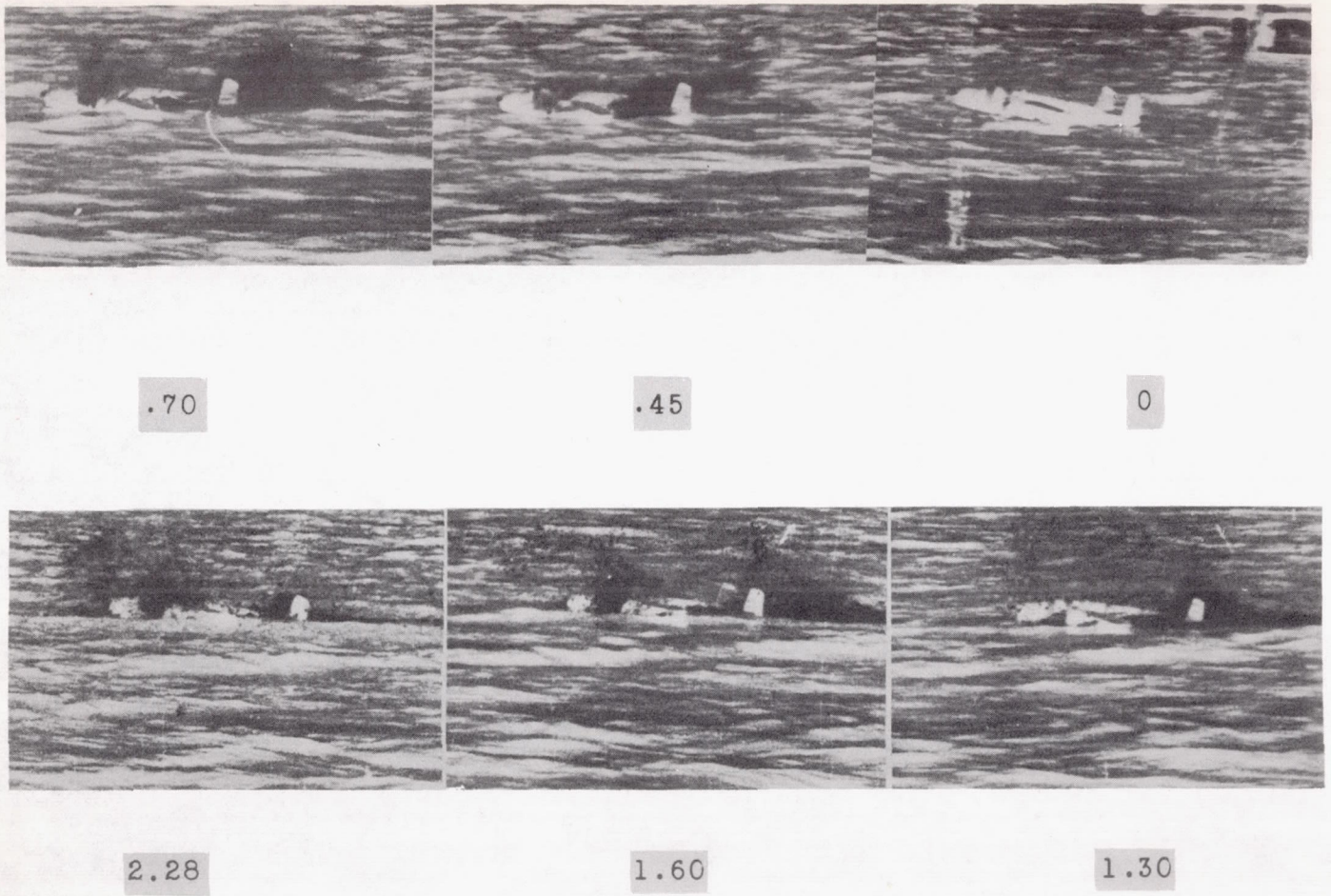

Figure 10.- Photographs of a ditching of a $\frac{1}{11}$-size model of the Army B-25 airplane. (Full-scale time intervals indicated in seconds.) Attitude 13°, flaps down 45°, speed 89 miles per hour full scale. Simulated failure of wheel and bomb-bay doors, camera and entrance hatches, bombardier's window, and bulkhead at after end of bomb bay.

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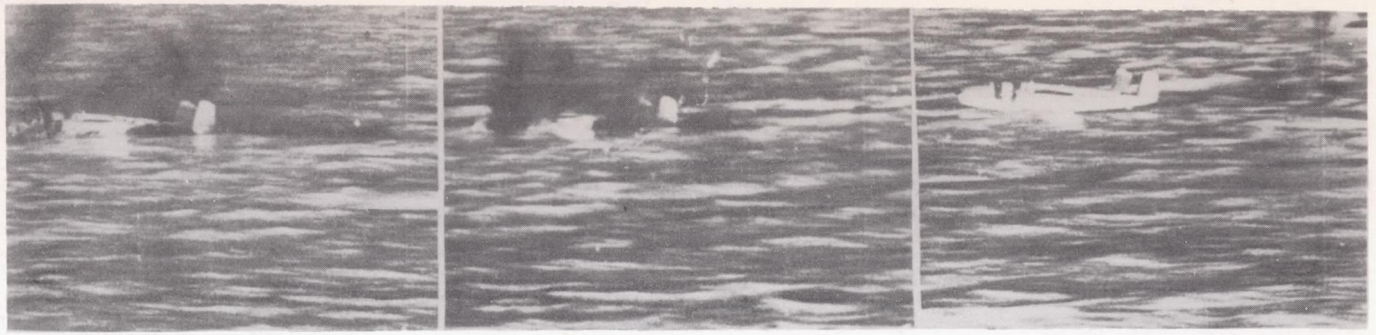

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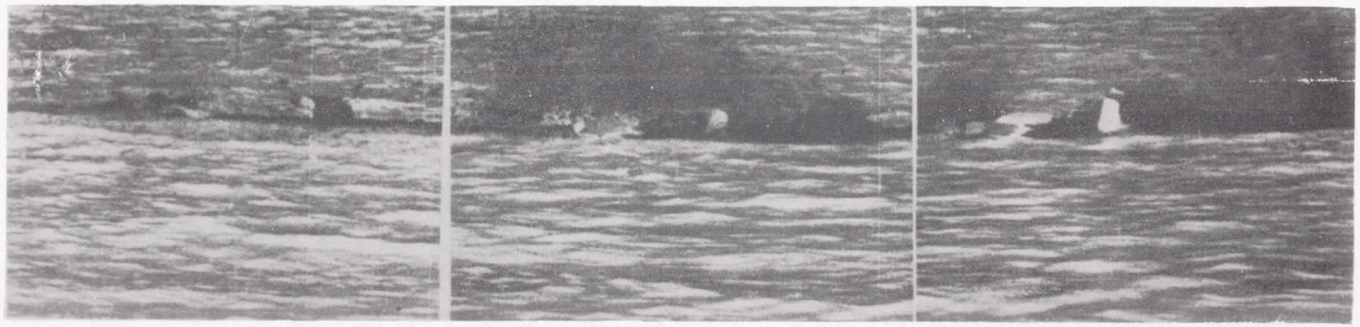

3.22 2.17 1.38

Figure 11.- Photographs of a ditching of a $\frac{1}{11}$-size model of the Army B-25 airplane. (Full-scale time intervals indicated in seconds.) Attitude 9°, flaps down 45°, speed 98 miles per hour, full scale. Simulated failure of wheel and bomb-bay doors, camera and entrance hatches, bombardier's window, and bulkhead at after end of bomb bay.

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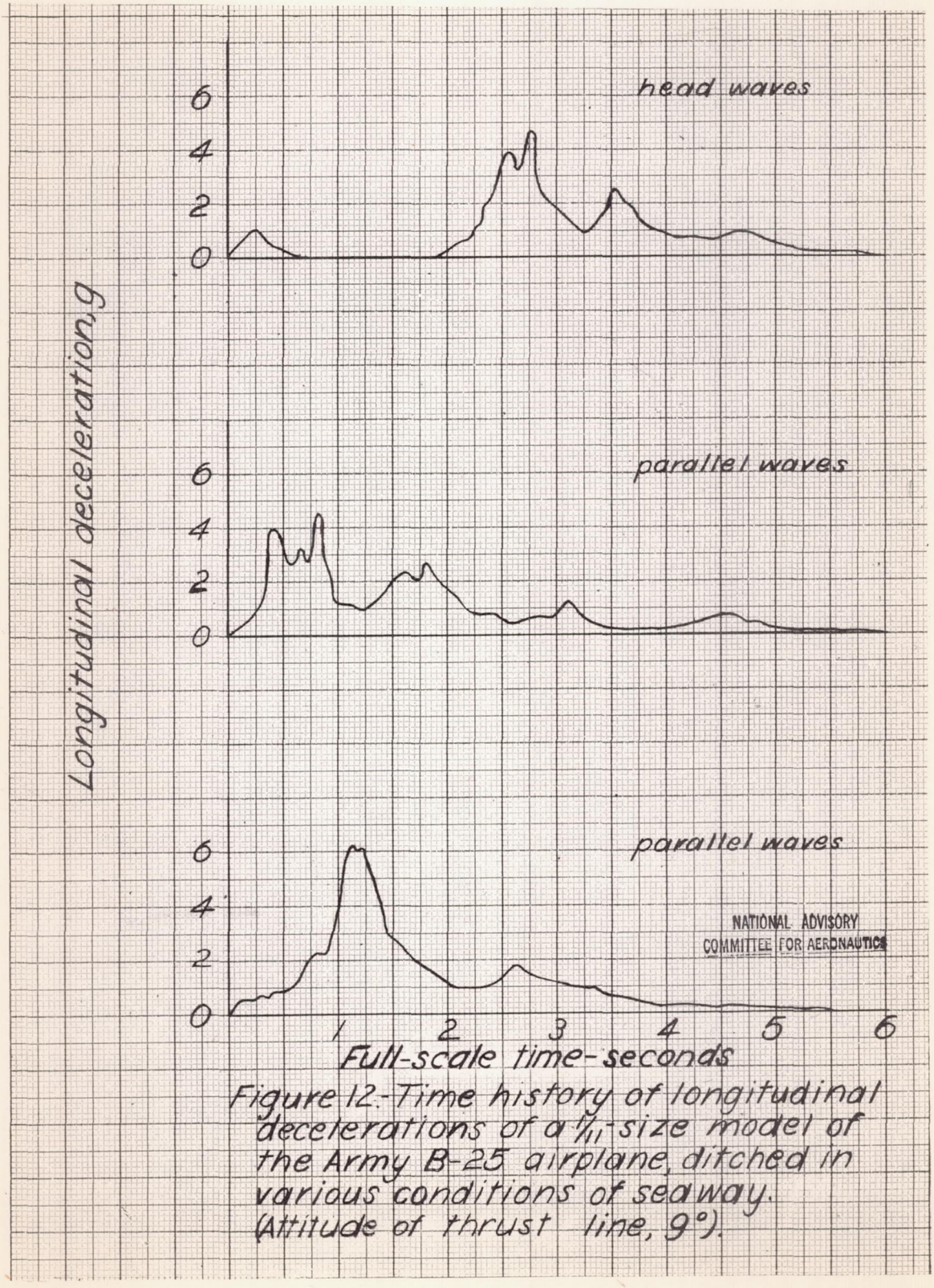

Figure 12.- Time history of longitudinal decelerations of a 1/11-size model of the Army B-25 airplane, ditched in various conditions of seaway. (Attitude of thrust line, 9°).

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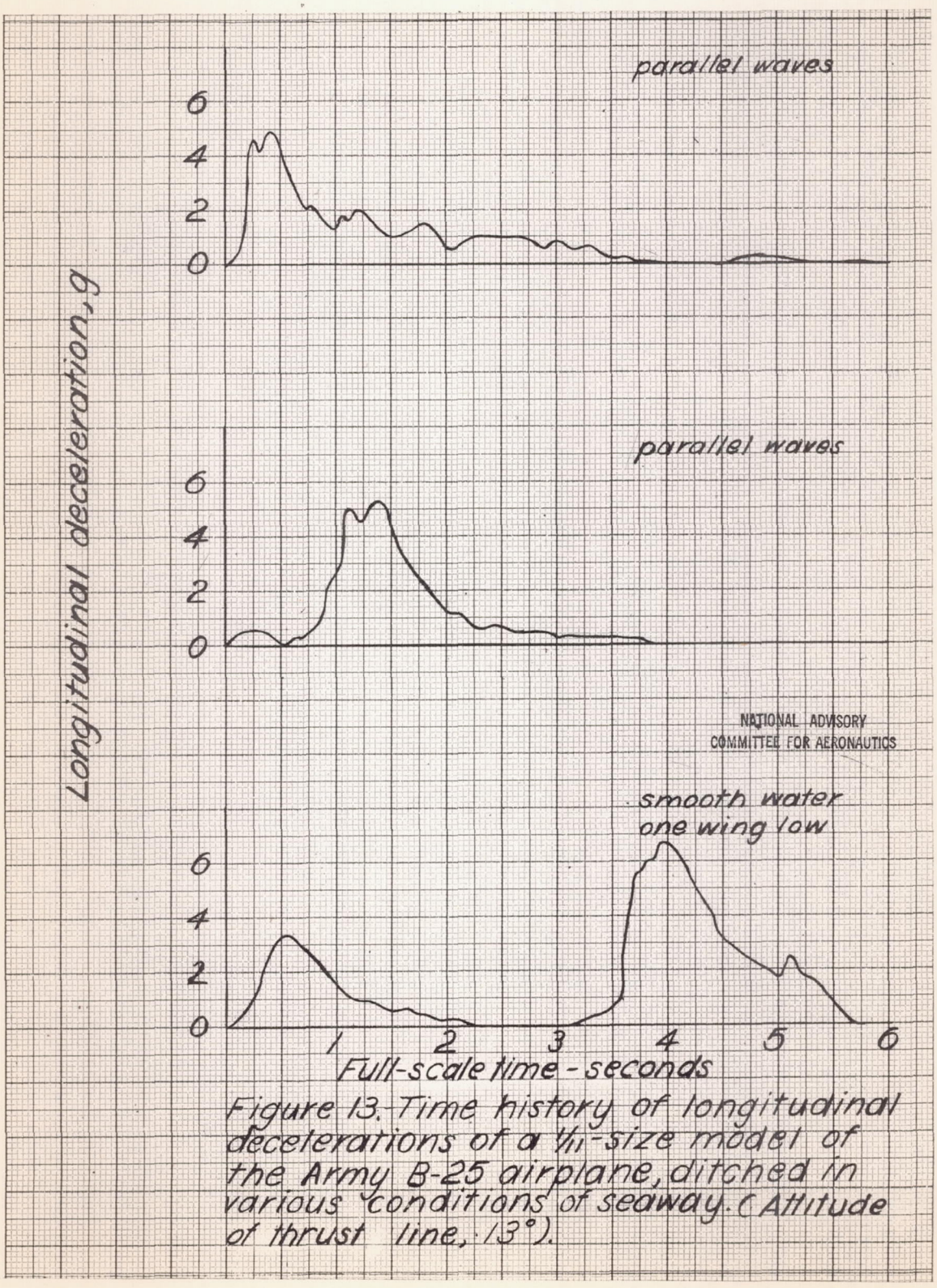

Figure 13. Time history of longitudinal decelerations of a 1/11-size model of the Army B-25 airplane, ditched in various conditions of seaway. (Attitude of thrust line, 13°).